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Supporting learning with weblogs in science education: A comparison of blogging and hand-written reflective writing with and without prompts

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Abstract. The goal of this study was to compare how weblogs and traditional hand-written reflective learning protocols compare regarding the use of cognitive and metacognitive strategies for knowledge acquisition as well as learning gains in secondary school students. The study used a quasi-experimental control group design with repeated measurements comparing weblogs and text-based reflective journals both with and without prompts. During a learning unit on the subject of climate change, students were assigned one to four experimental groups with different writing assignments and one control group that did not keep a learning protocol of any kind. Comparisons of pretest and posttest scores indicate that students in the experimental groups collectively outperform the students in the control group. Looking closer however, only the groups writing with the guidance of prompts showed better learning gains, while groups writing without prompts did not show significant differences when compared to the control group. There were no differences with respect to learning gains between groups writing weblogs and those writing with paper and pencil when supported by prompts. Without prompts however, students in the paper-and-pencil writing condition performed better than students writing blogs. For blogging students, prompts seemed to be more important to achieve greater learning gains. In addition, students showed greater use of cognitive and metacognitive strategies when guided by prompts. Also here, there were no differences with regard to the medium of writing. Both cognitive and metacognitive strategies were predictors of learning gains. In conclusion, the use of prompts can be considered as important scaffold when writing weblogs or paper based learning protocols.

Keywords: Weblogs, learning protocols, prompts, learning strategies, climate change

Introduction

Weblogs are regarded as a relatively novel and highly promising medium for promoting reflective and self-directed learning in higher education (Robertson, 2011; Sim & Hew, 2010) as well as in schools (Downes, 2004; Sawmiller, 2010). Weblogs are chronologically structured websites that facilitate the creation of individual or collective online journals. Additionally, weblogs have been considered to be an important part in the participative Web 2.0, where internet users are being facilitated to become authors (O'Reilly, 2005), and potential elements of personal learning environments (Attwell, 2007; Dabbagh & Kitsantas, 2012). In science education, the focus of digital media is currently shifting from digital resources to cognitive tools (Jonassen, 1995; Songer, 2010). Rather than delivering and displaying information, cognitive tools support student inquiry and meaning making. As cognitive tools, weblogs have the potential to support scientific reasoning through written reflection and online discussion in a community of inquiry (Angelaina & Jimoyiannis, 2012). However, their use for educational purposes raises multiple questions that need empirical clarification. First, it is important to determine the potentials that reflective writing has to

influence the learning process. Second, the question arises as to whether writing a weblog offers any advantages over traditional learning journals. Third, we need to better understand how to best provide teacher support for reflective writing with and without a weblog.

Theoretical Framework

Journal writing and blogging for learning

In educational settings, writing is a widely used method for improving learning and for reflecting on the learning process (Emig, 1977; Galbraith, 1999; Harris et al., 2011). Writing allows one to formulate thoughts in an explicit way and, by slowing down the process of thinking, to process them more thoroughly. Terms such as "learning diary," "learning journal," "learning protocol" and "reflective journal," are used to designate the written products when reflective writing is accompanying the learning process on a regular basis (Boud, 2001; Hiemstra, 2001; Moon, 2006; O'Connell & Dyment, 2011; Thorpe, 2004). These approaches have cognitive as well as metacognitive potentials.

The cognitive potentials of writing are fostered, when students are expected to write about taught material in their own words. In research about writing, this process is generally referred to as "writing-to-learn" (Klein, 1999; Newell, 2006) or "epistemic writing" (Bereiter, 1980) and it has been considered as a promising approach in many school subjects including science education (Baker et al., 2008; Rivard, 1994). Writing-to-learn represents an elaborated form of text production in which knowledge must be explicitly remembered, selected, summarized, structured, connected, put together with previous knowledge, elaborated, and, at times, further developed. Metacognitive potentials are promoted, when learning journals are used for the documentation of learning processes, the emphasis is on reflection about learning pathways and learning strategies. Both aspects have a close connection. Glogger et al. (2012) show that the quality and quantity of cognitive strategies that are ascertained from learning protocols are good predictors for learning outcomes.

In the learning process, learning strategies direct the interaction with and processing of information, and thus play an important role in learning (Pressley et al., 1985; Pressley & Harris, 2006; Weinstein, Acee & Jung, 2011; Weinstein & Mayer, 1986). Learning strategies consist of cognitive schemata that are deliberately applied by the learning subject in a controlled and purposeful way in order to achieve learning goals. In distinction to learning habits or learning styles, strategies suggest a greater degree of deliberateness. Learning strategies include all of the student's capacities for being consciously aware of and directing their own learning process, and, in this way, of achieving better learning success. Weinstein & Mayer (1986) classify learning strategies into five areas: repetition strategies, elaboration strategies, organizing strategies, monitoring strategies, and self-regulation strategies. Organizing, elaboration, and repetition strategies belong to the so-called cognitive learning strategies. They are useful for the direct absorption of information or to improve the processing and storage of knowledge. Monitoring and self-regulation strategies play a critical role in planning, monitoring, and evaluating one's own learning processes, and thus belong to what are known as metacognitive strategies.

Research on the topic of metacognition differentiates in a similar manner between cognitive knowledge and one's knowledge of how to regulate cognitions (Flavell, 1979; Schraw, 1998; Veenman, 2011). Metacognition and learning strategies are important prerequisites for self-directed learning (Boekaerts, 1999; Borkowski, 1996; Pintrich, 2000; Schunk, 2008; Zimmermann & Schunk, 2001), along with the abilities of co-regulation and shared

regulation when learning in a social context (Winne, 2011). Learning journals have been shown to be a promising method for activating cognitive and metacognitive learning activities, both in the university context (Cazan, 2012; McCrindle & Christensen, 1995), and in public schools (Harris et al., 2011; Mason, 1998). Learning journals may be hand-written or written using digital media, and the journal writing process may be undertaken with or without teacher support.

Compared to hand-written reflective journals, weblogs display a number of differences and specific potentials (Downes, 2004; Robertson, 2011; Sawmiller, 2010; Sim & Hew, 2010). Digital text entry is less linear, as text elements can subsequently be modified, expanded upon, erased, or moved. Additional advantages include the creative possibilities of working with formatting; incorporating tables, images, hypertext and multimedia. Studies show, that this has a positive impact on the quality of the texts (Goldberg, Russell & Cook 2003; Schwarz, 2004). As weblogs are online, they have a number of additional potentials (Andrés Martinez, 2012). It is possible for them to be managed as desired from any Internet-capable end terminal, such as smartphones, thus supporting the possibility of mobile learning. Internet-based learning journals are accessible from any location with a potentially global reach. Teachers, parents, and learning partners no longer have to gather the journals in hard-copy form to be able to read them. Online journals can make it possible not only for the individual student but also for learning groups to keep a learning journal. Comment and trackback functions can be used to promote feedback and establish a community of discourse (Xie, Ke & Sharma, 2008).

Options for instructional support

Although journaling is a practice-proven learning method, empirical studies make it clear that students do not spontaneously or automatically apply essential cognitive and metacognitive strategies for self-directed learning (Luckin et al., 2009; Nückles et al., 2004; Schwonke et al., 2006). Learning protocols that are written completely freely tend to read like content summaries and contain few indications of reflection upon or implementation of learning strategies. Research indicates that prompts and scaffolds are necessary to generate productive learning activity both in general instructional situations (Askell-Williams, Lawson, & Skrzypiec, 2012; King, 1992; Peters & Kitsantas, 2010; Pressley et al., 1992; Sitzmann & Ely, 2010) as well as in writing-to-learn interventions (Glogger et al., 2009; Klein & Yu, 2013; Nückles, Hübner & Renkl, 2009; Van den Boom, Paas, Van Merrienboer, & Van Gog, 2004). In their meta-analysis, Bangert-Drowns et al. (2004) showed that entirely free and undirected writing led to only small learning effects. Indeed, writing has a particularly positive effect on learning when the writing task encourages the conscious regulation of the learning process. Bereiter, Burtis & Scardamalia (1988) show that prompts are important to support school children in the development of knowledge-transforming writing. These scaffolds can be subdivided into cognitive prompts and metacognitive prompts. Cognitive prompts are directed toward a better understanding of learning content. Metacognitive prompts encourage conscious reflection about the learning strategies that have been used. Prompts may thus be regarded as strategy activators (Reigeluth & Stein, 1983) or as scaffolding that helps to orient students in applying learning strategies (Collins et al., 1989). However, Hübner, Nückles & Renkl (2007) only recommend the short-term use of such prompts. Over the longer term, prompts not only become superfluous for the students, but, at times, might even be experienced as thwarting autonomy. As in general theories on "human tutoring", the element of "fading" seems to be of some importance (Chi et al., 2001). In addition, Thillmann et al. (2009) showed that prompts might be more effective when applied at the appropriate time during learning.

Hypotheses

Based on our review of the literature, the aim of our study was to compare hand-written learning protocols to electronic learning protocols in the form of weblogs, using different levels of instructional support with respect to learning gains and the use of strategies. Based on the theoretical reasoning, the following hypotheses were stated:

H1: Students who write some kind of learning protocol (weblog or paper-based, with or without prompts) will achieve greater learning gains than those who do not write learning protocols at all.

H2: Students who write some kind of learning protocol (either weblog or paper-based) with the support of prompts will a) achieve greater learning gains and b) show a more intensive use of learning strategies than those who write some kind of learning protocol without the support of prompts.

H3: Students who write digital learning protocols with weblogs (either with or without prompts) will a) achieve greater learning gains and b) show more intensive use of learning strategies than those who write hand-written learning protocols.

H4: Knowledge related posttest results will be predicted by pretest results, the use of learning strategies and the experimental conditions.

Method

Sampling

Five separate 8th grade classes, totaling 104 students from three public middle schools (ISCED Level 2, extended level) in the Canton of Zürich, participated in the study. The sample was comprised of 58 girls and 46 boys with an age range between thirteen and sixteen (M=14.95; SD= .53). In selecting the classes, we took care that the classroom teachers had similar professional experience and that, up to the time of the study, no learning protocols or similar tools had been used in classroom instruction. In addition, the topic of "climate change," which was selected as the subject for the instructional unit because of its high degree of complexity, had not previously been the focus of instruction.

Study Design

The study is based on a quasi-experimental experimental design with repeated measurements (pretest-posttest-design). The 104 students were randomly assigned by class to four experimental groups and one control group (Table 1).

Table 1. Overview of the experimental groups and their sample sizes (n=104)

Student groups	Intervention	n
Experimental group 1	Learning protocol on paper with prompts (paper-prompt group)	19
Experimental group 2	Learning protocol on weblog with prompts (weblog-prompt group)	24
Experimental group 3	Learning protocol on paper without prompts (paper-no prompt group)	22
Experimental group 4	Learning protocol on weblog without prompts (weblog-no prompt group)	19
Control group	No learning protocol / no prompts	20

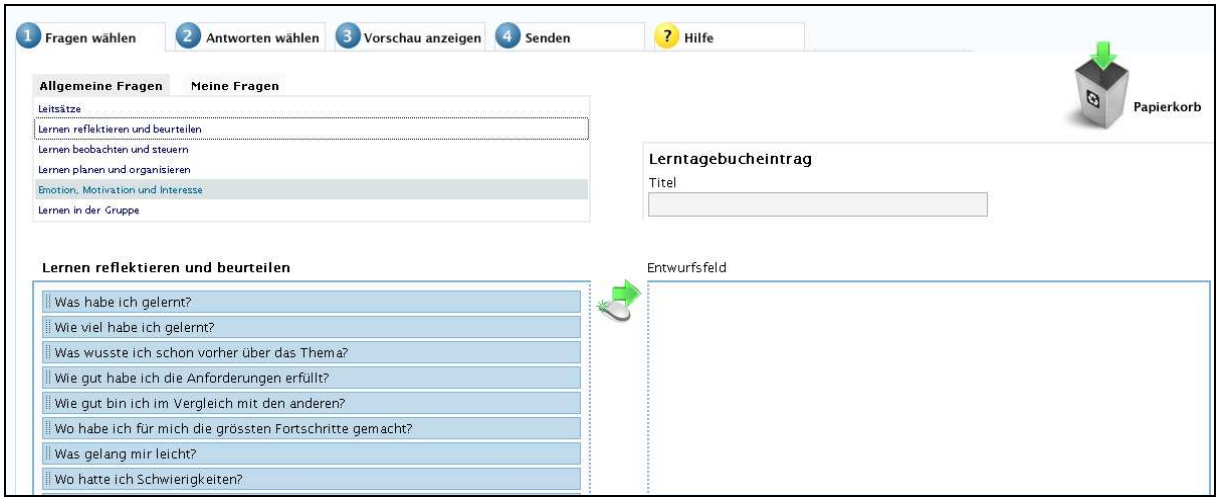

Figure 1. Screenshot of the teacher interface to generate prompts for student weblogs (in German)

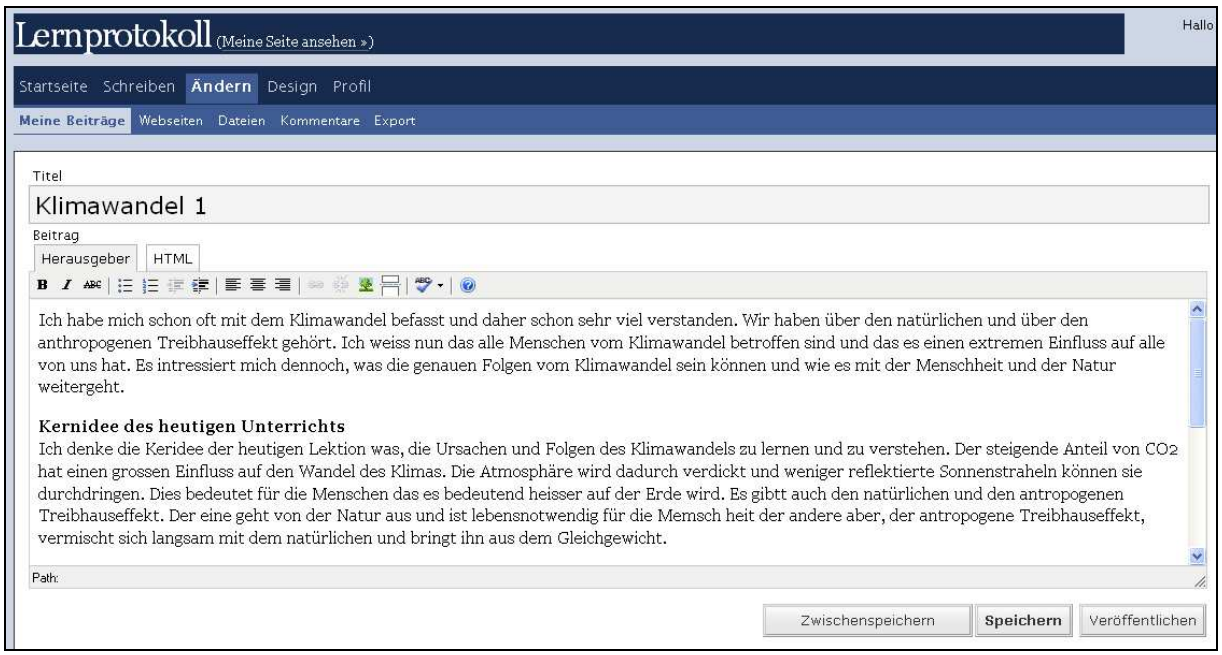

Figure 2. Screenshot of the student weblog writing interface (in German)

The assignment of classes to the study or control group was randomized. A complete randomization at the individual level was not possible within the organizational limits of this field experiment.

The students who wrote weblogs worked with Learninglog (www.learninglog.org), a software developed specifically for this purpose (Petko, 2011). Learninglog is based upon the open-source weblog program Wordpress (www.wordpress.org). A plug-in enhances the usual Wordpress program with many specific functions like group administration, writing assignments (Figure 1) and password protected entries (Figure 2). With these functions, the plug-in provides specific support for implementing the study design as outlined below.

Test instruments

For addressing the research questions and hypotheses, we measured a series of variables using different procedures.

Students' prior knowledge test

The students' prior content-related knowledge and their learning gains were assessed by means of a knowledge test, which consisted of four question-complexes with an open response format.

1. Can you explain what "climate change" means?
2. What do we mean by the "greenhouse effect?" What are its causes?
3. What are the consequences of global climate change on nature and on people's lives? Also think about which of these could affect you personally.
4. In your opinion, what must mankind do to stop global climate change? What could you do as an individual to specifically counter it?

To evaluate the knowledge test we anonymized all of the datasets from the pre- and posttests using codes. The evaluation was performed using the SOLO Taxonomy (Biggs & Collis, 1982) by two independent raters, who evaluated the open responses using a 6-step rating scale regarding the level of correctness, content about key aspects, connection points, conclusions, internal consistency, and structuring (0 = no response, 1 = prestructural, 2 = unistructural, 3 = multistructural, 4 = relational, 5 = extended abstract). The average kappa coefficient for interrater agreement was $\kappa = .65$, which indicates satisfactory inter-rater reliability (Landis & Koch, 1977). The four individual ratings for each test (SOLO 1-4) were summated to obtain an overall value (maximum value of the summated index = 20).

Learning protocols coding scheme

To evaluate the learning protocols with respect to the use of cognitive and metacognitive strategies, we developed a category system derived from an existing instrument developed by Hübner, Nückles and Renkl (2007) for assessing cognitive and metacognitive activity across six dimensions. For each learning protocol, the analysis was conducted along a 5-step rating scale (1 = not at all, 2 = hardly ever, 3 = somewhat, 4 = clear, 5 = outstanding) in the following dimensions: Organization 1: Expressing key points and their connections; Organization 2: Establishing relationships between new knowledge elements; Organization 3: learning protocols are meaningfully structured; Elaboration: Establishing relationships and points of connection to previous knowledge; Self-control: monitoring one's own process of understanding; Self-regulation: actively dealing with problems of understanding, searching for solutions, taking responsibility for one's own learning process. In line with the research outlined above, « Organization 1-3» and «Elaboration » can be labelled « cognitive learning strategies » for they are more closely related to understanding the content at hand, while « Self-Control » and « Self-Regulation » are considered to be a rather metacognitive strategies as these are seen as more general ways of reflecting on one's learning that goes beyond the comprehension of the given topic. The learning protocols were evaluated by two raters. The average kappa coefficient was $\kappa = .78$, which once again indicates substantial interrater reliability (Landis & Koch, 1977).

Conducting the experiment

The experiment drew on eight 45-minute classroom lessons from a teaching unit called "Man and Environment." In the fourth and sixth lessons, the students of the experimental groups each spent 45 minutes writing a learning protocol, in accordance with their experimental group assignment. The prompt-groups were given seven "prompts" in advance for writing their learning protocols, which were intended to stimulate the use of both cognitive and metacognitive strategies:

1. What key points in today's lesson did you understand? What key points haven't you understood yet? Reasons?
2. Take another brief look through the papers from today's lesson. Formulate the most important points in your own words.
3. Try to organize the materials in your learning protocol in such a way that you can readily notice how everything is connected (build common threads / use heading and subheadings, etc.).
4. Before today have you heard, read about, or had some experience with the subject that was just taught in class?
5. What is your opinion about the subject and what other questions would be of interest to you?
6. What parts of today's lesson do you need to think about one more time in order to be sure you really understand everything?
7. What steps could you take for solving any remaining problems in understanding?

These prompts were adopted from the study by Hübner et al. (2007) and the language was adapted to the age of the target group. The experimental no-prompt groups were given only general instructions along the lines of "write a learning protocol about the lesson just completed." In the experimental group 1 (paper-and-pencil with prompts) we handed out worksheets with these prompting questions to structure students' writing. In the experimental group 2 (weblog with prompts) these seven questions were added to the text entry window per default each time students composed a new weblog entry.

Methods of analysis

All statistical computations were performed using IBM SPSS Statistics 20. The statistical analyses were based upon a significance level of alpha ≤ .05. The assessment of effect size (partial η2) was done using the methods of described by Cohen (1992; 1988), by which, for simple comparisons, .20 < d <. 50 is considered to be a small effect, .50 < d < .80 a medium and d > .80 a large effect. For multiple comparisons we use η2 <.06 counting as a small effect, .06 < η2 < .13 as a moderate effect, and η2 >.13 will considered to be a large effect. For correlation analysis, effect sizes of the r-family are used with r > .10 as a small, r > .30 as a medium and r > .50 as a large correlation. For multiple regression analysis, we use f^2 with .02 < f^2 <.15 as small, .15 < f^2 <.35 as medium and f^2 >.35 as a large effect.

Results and Discussion

Because assignment to the experimental groups was randomized by class and not individually, it is important to first compare the groups according to various relevant variables, such as age, most recent report card grades (in the subject areas of mathematics, language, geography, and biology), intelligence (IQ measured by CFT 20-R: Weiss, 2008), and previous knowledge of the specific content in the pretest. No significant differences were shown between the groups for any of the variables tested.

Effects of experimental conditions on content-related learning gains

Both the experimental groups and the control group showed a significant improvement in their knowledge about climate change (Table 2). The effect sizes (Cohen's d) were greater than d>2 for the experimental groups and just under this threshold for the control group.

Table 2. Means and standard deviations of student's pretest and posttests results on the subject of climate change according to the SOLO Index (scoring scale: 0 – 20) by groups

Source	Pretest Content-specific knowledge (SOLO-Index) t1		Posttest Content-specific-knowledge (SOLO-Index) t2	
	M	SD	M	SD
(1) Paper-prompt group	7.42	(1.54)	12.53	(1.81)
(2) Weblog-prompt group	7.42	(1.82)	12.00	(2.11)
(3) Paper-no-prompt group	7.73	(1.39)	11.41	(1.68)
(4) Weblog-no-prompt group	6.37	(2.09)	10.68	(1.97)
(5) Control group	7.30	(1.75)	10.40	(1.76)

To test the differences, we used a repeated measures ANOVA, with group membership as the between-subjects factor and the test results at t1 and t2 as the within-subjects factor. The overall interaction effect between "learning protocol conditions" and "test results" turns out to be significant, $F(4, 99) = 4.23$, $p < .01$, partial $\eta 2 = .15$. In detail, the post-hoc test (LSD) shows a number of significant group differences with respect to their learning gains ($p < .05$). Students in the "paper with prompts" group achieved significantly greater learning gains than the students in the "weblog without prompts" group or the students in the control group. The "paper without prompts" intervention group achieved significantly greater learning gains than the "weblog without prompts" intervention group. Moreover, there was a significant difference between the means in the "weblog with prompts" group and the "weblog without prompts" group in favor of the intervention group with prompts ($p < .05$). Based on these findings, we are inclined to conclude that H1 has been disproved as it turned out that not all experimental groups achieved better than the control group. However, if we compare learning gains of the treatment groups taken together (N=84, Mt1=7.26, SDt1=1.76, Mt2=11.67, SDt2=1.98) with the scores of the control group (N=20, Mt1=7.30, SDt1=1.75 ; Mt2= 10.40, SDt2 =1.76) we find a significant advantage for the experimental groups who write learning protocols, $F(1, 102)=9.05$, $p<.01$, partial $\eta 2 = .08$. However this supports H1, this observation could be an effect of the prompting rather than the learning protocol writing.

To test the hypotheses H2a and H3a, a priori contrasts have been computed (Tabachnick & Fidell, 2012). Supporting hypothesis H2a, the prompt groups achieved significantly greater learning gains than the no-prompt groups, $F(1, 99) = 5.19$, $p < .05$, partial $\eta 2 = .05$, and the control group, $F(1, 99) = 5.28$, $p < .05$, partial $\eta 2 = .05$. The no-prompt groups did not show greater knowledge gains than the control group, $F(1, 99) = .44$, ns.. To check hypothesis H3a, we tested whether the potential differences in learning gains might be associated with the writing medium. The subsequent analysis of variance showed no significant difference between the weblog-prompt group and the paper-prompt group with respect to learning gains, $F(1, 99) = .27$, ns. Finally, the paper-no-prompt group achieved significantly greater learning gains than the weblog-no-prompt group, $F(1, 99) = 4.38$, $p <.05$, partial $\eta 2 = .04$.

Effects of the experimental conditions on the use of cognitive and metacognitive strategies in the learning protocols

In the following chapter, we present the results for the statistical analysis on the question whether the choice of the writing medium and the support of prompts have an effect on the use of learning strategies in the first learning protocol (LP1) and the second learning protocol (LP2) as rated by the researchers. The descriptive analysis shows that there are some differences in the means between the experimental groups (Table 3).

Table 3. Student's display of learning strategies in their writing (rating scale: 1 – 5): Means and standard deviations for the first learning protocol (LP1) and the second learning protocol (LP2) by groups

Variables	Paper prompt group	Weblog prompt group	Weblog no-prompt group	Paper no-prompt group
	M (SD)	M (SD)	M (SD)	M (SD)
Organizational strategies 1 (key points) in LP1	3.79 (.79)	3.46 (1.02)	3.47 (.51)	3.27 (.88)
Organizat. strategies 2 (internal structure) in LP1	3.68 (.89)	3.17 (.70)	3.16 (.69)	3.86 (.83)
Organizat. strategies 3 (external structure) in LP1	3.05 (.85)	2.88 (.99)	3.63(1.01)	2.27(1.20)
Elaboration strategies in LP1	2.84 (1.21)	2.58 (1.02)	1.16 (.38)	1.50(1.01)
Self-control strategies in LP1	2.95 (1.39)	2.83 (1.13)	1.05 (.23)	1.64 (.95)
Self-regulation strategies in LP1	2.58 (1.39)	2.12 (1.15)	1.00 (.00)	1.05 (.21)
Organizational strategies 1 (key points) in LP2	3.58 (.90)	3.37 (.92)	3.16 (.50)	3.59 (.96)
Organization strategies 2 (internal structure) LP2	3.53 (.61)	3.25 (.94)	2.95 (.78)	3.82 (.73)
Organization strategies 3 (external structure) LP2	2.89 (.81)	3.08 (1.06)	3.05(1.13)	2.00(1.11)
Elaboration strategies in LP2	2.75 (1.33)	2.37 (1.12)	1.11 (.32)	1.18 (.66)
Self-control strategies in LP2	2.53 (1.22)	2.58 (1.02)	1.00 (.00)	1.68(1.09)
Self-regulation strategies in LP2	1.58 (.90)	2.00 (.98)	1.00 (.00)	1.00 (.00)

When testing hypothesis H2b, we found significant differences between the prompt groups and the no-prompt groups with respect to the number of cognitive and metacognitive learning strategies used in their learning protocols. This is the case for both Learning protocol 1, Pillai's Trace = .51, $F(7, 77) = 13.34$, $p < .001$, and Learning protocol 2, Pillai's Trace = .45, $F(6, 77) = 10.46$, $p < .001$. Follow-up analyses using Mann-Whitney's U test showed that for both learning protocols, the prompt-groups differed to a highly significant degree from the no-prompt-groups in the strategy dimensions "Elaboration", "Self-regulation", "Self-control" and "Organizational strategies 3" for LP2. For the use of organizational strategies, no significant differences were demonstrated between the two groups.

To test hypothesis H3b, we examined whether the weblog-prompt group showed a greater number of cognitive and metacognitive strategies than the paper-prompt group. The multivariate analysis showed that the weblog-prompt group and the paper-prompt group did not differ significantly from each other with respect to the number of cognitive and metacognitive learning strategies in the learning protocols. This was the case for both Learning protocol 1, Pillai's Trace = .90, $F(6,36) = .59$, ns., and for Learning protocol 2, Pillai's Trace = .10, $F(6,36) = .66$, ns. Because of the non-significant findings, we did not perform a follow-up analysis. Additionally, we tested whether the learning protocols of the weblog-no prompt group contained a greater number of cognitive and metacognitive strategies than those of the paper-no-prompt group. Our multivariate analysis of variance showed that the weblog-no-prompt group and the paper-no-prompt group differed significantly from each other with respect to the number of cognitive and metacognitive learning strategies used. This effect was seen in both the first learning protocol, Pillai's Trace = 44, $F(6,34) = 4.40$, $p <$

.005, and in the second learning protocol, Pillai's Trace = .60, $F(6,34) = 8.46$, $p < .001$. Follow-up analysis using Mann-Whitney's U test showed that the groups differed significantly in Learning Protocols 1 and 2 with respect to the variables "Organizational Strategy 2", for LP1, $U = 113.50$, $p < .01$; Organizational Strategy 2, for LP 2, $U = 93.50$, $p < .01$, "Organizational Strategy 3," for LP1, $U = 92.00$, $p < .01$; "Organizational Strategy 3," for LP2: $U = 109.00$, $p < .05$, and also for "Self-control" for LP1, $U = 141.50$, $p < .05$; "Self-control," for LP 2: $U = 142.500$, $p < .01$. However, for learning protocols without prompts, only the effect for the organizational strategy "meaningfully structuring learning protocols" turned out to favor learning protocols written online.

To test H4, we computed correlations between the observed learning strategies and the knowledge scores in t1, t2 as well as the knowledge gain score. For this analysis, we computed a mean score for each type of learning strategy across the two learning protocols. To test our hypothesis 4, Pearson correlations with a Bonferroni-corrected two-tailed significance level of $p \leq .05$ were employed (Table 4).

Table 4 shows moderately positive and significant correlations between cognitive learning strategies (1) and (2) and posttest knowledge scores. The strategy (1) of summarizing key points was also positively correlated with knowledge gains. Metacognitive learning strategies did show moderate but not quite significant correlations with posttest scores and knowledge gains. Learning strategies did not seem to be related to pretest scores.

To explore these findings further, we computed a linear regression with posttest scores as the dependent variable and all others as independent variables. Also, we included experimental group membership as dummy coded additional variables. The final model with significant predictors only is shown in Table 5. The regression analysis showed that 51% of the variance in posttest knowledge scores can be explained with three variables: pretest content specific knowledge, the application of learning strategies focusing on the writing of key points and self-control strategies, i.e. monitoring one's own understanding and comprehension difficulties.

With an $f^2 = 1.04$ this can be considered to be a large effect. Other learning strategies turned out as not significant, mostly due to issues of collinearity. Also, the inclusion of the dummy coded experimental group membership variables did not improve the model.

Table 4. Pearson correlations between learning strategies observed in the learning protocols and weblogs, pre- and posttest-knowledge and knowledge gain scores

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Organisational strategies 1 (key points)								
(2) Organisational strategies 2 (internal structure)	.62***							
(3) Organisational strategies 3 (external structure)	.24	.01						
(4) Elaboration strategies	.04	-.04	.07					
(5) Self-control strategies	.07	.11	.03	.68***				
(6) Self-regulation strategies	-.12	-.09	.06	.63***	.71***			
(7) Prestest Content-specific knowledge (SOLO t1)	.05	.17	-.14	.21	.08	.13		
(8) Posttest Content-specific-knowledge (SOLO t2)	.35*	.36*	-.01	.32	.34	.25	.54***	
(9) Gain Score (SOLO-Index t2-t1)	.35*	.24	.13	.15	.31	.16	-.37**	.58***

*p < .05, **p < .01, ***p < .001, with Bonferroni corrections

Table 5. Linear regression with Posttest Content-specific knowledge (SOLO-Index t2) as dependent variable

Predictors	R^2	b	SE	beta
Post-test Content specific knowledge, F(3, 80) = 27.89***	.51			
(7) Pre-test Content-specific knowledge (SOLO t1)		.61	..09	.54***
(1) Organisational strategies 1 (key points)		.86	.22	.31***
(5) Self-control strategies		.48	.14	.28**

N= 84, *p < .05, **p < .01, ***p < .001

Conclusions

The study tried to answer the question whether weblogs are equally if not better suited to be used as a learning tool when compared with traditional learning protocols on paper. In theory, weblogs are expected to be more efficient due to their advantages as a digital online medium for writing and discussion (Downes, 2004; Robertson, 2011; Sawmiller, 2010; Sim & Hew, 2010). In combination, we wanted to test the assumption that prompts given by the teacher lead to better learning gains and a more intensive application of learning strategies in weblogs as well as in traditional learning protocols (Glogger et al., 2009; Klein & Yu, 2013; Nückles, Hübner & Renkl, 2009; Van den Boom et al., 2004). The findings of our field experiment with 104 secondary school students over a period of eight lessons show that although, taken together, our experimental groups outperformed the control group, not all variants of writing learning protocols compared equally favorable (H1 disproved). Instead, it seems to matter how the writing process was guided. Students who wrote their learning protocols with the support of prompts not only achieved greater learning gains in comparison with the control group, but also in comparison with those experimental groups that wrote learning protocols without instructional support through prompts (H2a confirmed). In the learning protocols written by the prompts groups, there were a greater number of contributions that indicated the specific use of metacognitive and cognitive strategies (H2b confirmed).

The present study thus underscores the finding already shown in other studies (e.g. Nückles, Hübner & Renkl, 2009) that prompts are of great significance for learning and learning-related reflection through writing. As a new finding that goes beyond previous results, our study showed that the choice of writing medium – weblog versus paper and pencil – had no effect on learning gains as long as writing was supported by prompts (H3a disproved). However, when writing the learning protocols took place without the support of prompts, the experimental group that wrote learning protocols on paper achieved greater learning gains than the group that wrote their protocols online. This finding is surprising, and it is difficult to reach a plausible explanation without further inquiry. It is possible that technical difficulties that arose in using the weblog software were responsible for the fact that learners were better able to concentrate on learning content when using paper and pencil. When a rather novel medium like weblogs are used, prompts may serve as activators to overcome possible negative effects that might come along with the uncertainties of the new writing situation. The analysis of the written content shows that a significantly greater number of organizational strategies that were aimed at arranging the text were used in the electronic learning protocols when compared to their paper and pencil counterparts (H3b confirmed in one sub-dimension). This finding is less surprising, because a specific advantage of computer based writing versus handwritten text creation is that it makes it possible to develop the text in a non-linear fashion and to subsequently rearrange and

correct existing texts. As shown in our regression analysis, pretest-knowledge, organizational strategies and self-control-strategies accounted for 51% in the variance in posttest-knowledge. While no direct effects of treatment group membership were found, there still might be mediated effects that need further investigation.

In summary, the study shows that writing learning protocols leads to greater learning gains if the writing is guided with prompts. Prompts also have a positive effect on the application of cognitive and metacognitive strategies that lead to better knowledge gains. By contrast, unguided writing often results in a general content summary of the instructional materials, but not in deeper information processing or reflection about what was learned. The selection of the writing medium (weblog or paper) appears to play a subordinate role as compared to instructional support by means of prompts. Weblogs can even show worse effects than paper-and-pencil writing if not supported by prompts. This should lead to some caution, when employing weblogs as a new substitute for traditional learning protocol approaches. Future research needs to focus on the specifics of how writing weblogs for learning can be supported by teachers.

Of course, our study has a number of limitations that need to be taken into account. Not all features of the weblogs were included in the intervention. For example, the option to mutually comment on each other's entries was not employed while this might be a central element of a successful blogging experience (Ellison & Wu, 2008; Hall & Davison, 2007). Similarly, tagging and the categorization of entries were not part of the present study, nor were the options for managing learning protocols not only as text but also in the form of drawings, mind maps, audio or video, and for linking them with the option of mobile learning. Also, we have to assume that the length of the intervention was too brief for the learners to become accustomed to their weblogs or to turn them into an integral part of their "personal learning environment". It is possible that novelty effects and operational difficulties could have played a role. In addition, prompts were presented as a writing instruction in advance. This might also be a limiting factor as it seems to be better to present prompts adaptively during the writing intervention (Thillmann et al., 2009). Beyond this, the present study also has certain methodological limitations. Since complete randomization at the individual level was not possible within the quasi-experimental setting, there is a risk that the effects of independent variables could have been confounded by other variables– even though we did make a deliberate attempt to control for various independent variables. In addition, the sample sizes are relatively small. Yet the fact that they show significant differences despite the small intervention groups may be an indicator that research on prompts for blogging may be an important area for future research.

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